# EXPERIMENTAL TESTS OF TWO HYPOTHESES CONCERNING THE DETERMINANTS OF FUNCTION FLUCTUATION



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# EXPERIMENTAL TESTS OF TWO HYPOTHESES CONCERNING THE DETERMINANTS OF FUNCTION FLUCTUATION

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# SYNOPSIS

## EXPERIMENTAL TESTS OF TWO HYPOTHESES CONCERNING THE DETERMINANTS OF FUNCTION FLUCTUATION

Two hypotheses concerning the determinants of function fluctuation were tested in this investigation. The first hypothesis tested was that the extent to which performance on a cognitive test shows evidence of fluctuation is correlated with and determined by the extent to which a test is speeded. A comparison of criteria and indices derived from relatively speeded and relatively power tests of cognitive functions indicated that fluctuation was significantly more extensive in the latter. Thirteen out of eighteen criteria for the power tests were significant, while only one out of eighteen criteria for the speeded tests was significant.

The second hypothesis tested was that the extent to which performance on a cognitive test shows evidence of fluctuation is correlated with and determined by the extent of fatigue. A com-

parison of criteria derived from students having ingested amphetamine sulfate capsules and students having taken placebo capsules indicated that fluctuation was significantly more extensive in the latter. Fluctuation was even more significant in the group not taking any capsules.

The recommendation is made that when an important educational decision is being made concerning any known fluctuating function, particularly if the subject is at the borderline or threshold, it would seem advisable to test the child after a medically acceptable dose of amphetamine sulfate has been administered.

# CHAPTER I

## THE THESIS PROBLEM AND ITS BACKGROUND

### I. INTRODUCTION

It is generally agreed that mental functions are not stable, that measures of the amount of an individual's performance in any one function are uneven across many testing occasions. This was first stated clearly by Thouless (1936) who labelled this phenomenon function fluctuation and described it using a sample model.

Any test score is a somewhat inaccurate measure. When two test measurements of the same individual are made at different times there is often a difference between the two measures. The difference observed may be due to two causes. First, it may be due to unreliability of the test, that is, to failure of the test to give identical results when used to measure equal quantities of the same function. Secondly, it may be due to the fact that the function measured in the individual has itself changed. The first cause of variation is always present to some extent. The second cause of variation is a real variability in the function being measured. Thouless (1936) used the term function fluctuation to refer to this measure of genuine quantitative change in

individual performance between testing occasions. Some authors use the term "quotidian variability" synonymously with function fluctuation. In this study the term "function fluctuation" will be used to refer to this real day-to-day quantitative variation in the function tested.

Thouless (1936) provided the experimental and statistical techniques necessary for the experimental investigation of function fluctuation. Anderson (1958) using these techniques provided evidence that fluctuation was characteristic of the cognitive functions of children of average age eleven years, and concluded:

> The implication of these results is that, before tests of any kind are published or used, an investigation of whether the trait under measurement is a fluctuating one should be made, and each new published test should be accompanied by an estimate of the most probable extent of fluctuation characteristic of it. Again tests of a fluctuating function, which is being used in a psychological experiment, should be repeated a number of times and any statistical analysis based on the average performance by the individual. If this were followed universally, results and conclusions from similar experiments with equivalent groups would be more invariant and consistent than has been the case (1958, p. 92).

## II. THE PROBLEM

Even though most psychologists agree that function fluctuation does occur, very few have attempted to discover by experimental means what some of the determinants

or correlates of function fluctuation are. Some of the possible determinants that have been suggested and abandoned are: age, sex, ability, and personality (Anderson, 1958). This study was undertaken to test the following hypotheses:

1. The extent to which performance on a cognitive test shows evidence of fluctuation is correlated with and determined by the extent to which a test is speeded. This hypothesis was expressed by Anderson (1960), on the basis of an experimental survey of the differences in the amount of fluctuation characteristic of relatively speeded and relatively non-speeded subtests of the Terman-McNemar Test of Mental Ability.

2. The extent to which performance on a cognitive test shows evidence of fluctuation is correlated with and determined by the extent of fatigue.

Two subsidiary aims are:

1. To establish whether the performance of Canadian children on the Moray House Intelligence Test shows an amount of fluctuation approximately similar to that of English children studied by Anderson (1959).

2. To examine the significance of sex differences in function fluctuation.

# CHAPTER II

## SPEED AND POWER EFFECTS ON PERFORMANCE ON COGNITIVE TESTS

When an examination of contemporary cognitive tests is made, it is readily observed that they differ from each other in many ways; not least is the extent to which the test is one of 'speed' or one of 'power'. Perhaps some tests call more for quick and possibly superficial responses, while others measure the depth of our understanding rather than its quickness (Eysenck, 1953).

The problem of speed and power in intelligence testing has been left dormant by psychologists for many years and research has not been directed toward its solution. Recently, interest in the problem has been re-awakened (Eysenck, 1953), and as some of the experimental findings are of very great importance they shall be discussed here briefly.

Most group tests of ability are given with a time limit. Cronback (1960) suggests that it is doubtful whether an ability test should be speeded. Table I indicates the effect on score when pupils are given added time on three typical tests.

TABLE I

EFFECT OF GIVING PUPILS ADDITIONAL TIME ON GROUP INTELLIGENCE TESTS (CRONBACK, 1960, p. 222)

| Age of Pupils | Number of Pupils | Test | Standard Time | Extra Time | Mean Points Earned in Standard Time | Mean Points Earned in Additional Time |
|---|---|---|---|---|---|---|
| 9 - 10 | 223 | Otis Alpha Non-Verbal | 20 min. | 30 min. | 65.0 | 1.1 |
| 9 - 10 | 226 | Henmon-Nelson | 30 min. | 20 min. | 54.1 | 3.4 |
| 13 - 14 | 235 | Otis Beta (Verbal) | 30 min. | 15 min. | 60.4 | 0.9 |

It is quite evident that most pupils finish in the standard time all the items they can do. However, Cronback feels that for occasional cases, speed will be the principal factor determining scores.

Ayers (1953) suggests that although studies, such as the one just cited, have generally shown a high degree of correlation between speeded and unspeeded scores, there is an optimum time limit for any given test. He hypothesizes that: ". . . the optimum limit for a test is that time which will yield maximum variance and reliability while maintaining a symmetrical distribution of test scores" (1953, p. 81).

Myers (1952) attempted to compare the validities of short nonverbal reasoning tests when different numbers of items were given within the same time limits. The criteria for validity were grades and grade averages for the first year at the United States Naval Academy at Annapolis. Three forms of a figure-classification test were given to six hundred midshipmen. The forms were made up of five twelve-minute parts, these parts including either ten, twenty, or thirty items with at least one part of each form at each speed level. Correlations were computed between scores on the different parts, and also between the parts and the grades in the first

year's work at the Academy. These intercorrelations were analyzed by factorial methods. Myer's results led him to conclude that the score on speeded tests is a function of two orthogonal factors, the factor of ability and the "rate-of-answering" (1952, p. 352) factor.

The assumption is often made that those who are able to solve difficult problems in a test will work more quickly than those who cannot. This study suggests that this may not always be the case. In an attempt to explain this finding Myers advances the hypothesis that for some speeded tests not every mark on the answer sheet represents a subject's reasoned conception of an adequate solution. Many of the answers may be guesses, although not necessarily random answers. The group of subjects who reach the end of a speeded test may include some who can solve the problems quickly and also some who answer the problems before they complete the solutions. These subjects may not understand what they are expected to do or they may prefer to guess in order to work quickly. Thus, two scores that are identical may, in effect, depict two very different individuals with very different abilities.

There is evidence, according to Vernon (1958),

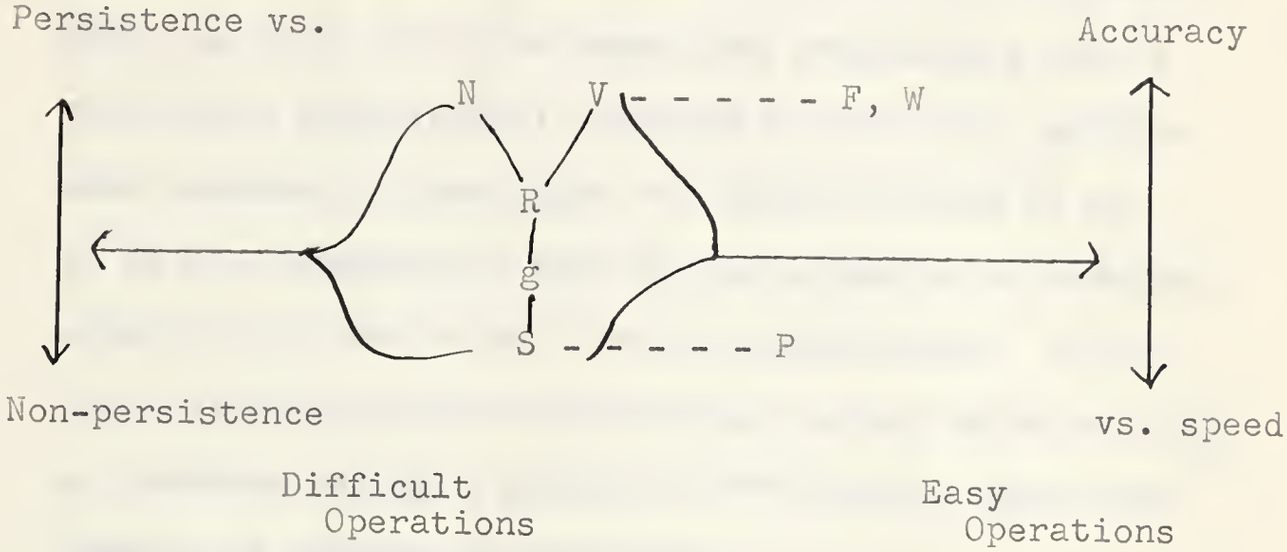
that the speed and difficulty characteristics of a test considerably affect its factorial content. Thus when Verbal Fluency tests are given to children or poorly educated adults, for whom the rapid production of words is a difficult task, correlations with vocabulary or other V tests become so high that it is hardly possible to distinguish W or F from V factors.

Again Zimmerman (1954) has shown that P, perceptual speed, shades into Spatial or Visualization abilities when the difficulty level rises, though he failed to confirm his theory that S-factor turns into R or reasoning when the test is still more difficult. Vernon (1958) refers to a fairly large-scale study of this problem, which was undertaken by Mangan, who applied thirty-eight ability tests under varied conditions of speed to two hundred twelve-year-old boys. While the usual content factors emerged clearly, most tests were also loaded either on speed or on persistence factors.

Vernon suggests that the 'content-factors', g, V, N, S, etc., cannot ever be measured in isolation, but are always conditioned by the kind of work-attitude that the test instructions and timing impose. Vernon attempts to depict this conception diagrammatically.

FIGURE 1

DIAGRAM OF CONTENT AND WORK-ATTITUDE FACTORS (VERNON, 1958, p. 36)




He makes the following comment:

> Among the chief work-attitude factors are persistence and speed vs. accuracy . . . the former affecting all results on difficult power tests given with ample or unlimited time, the latter entering when the material is very easy. Such a conception has not been generally realized previously because most investigators have either confined most of their tests to much the same timing and difficultylevel (so that the work-attitude was a fairly constant factor throughout and indeed often became confounded with g), or else tried to name factors derived largely from speed-difficulty differences in terms of psychological contents or functions (Vernon, 1958, p. 36).

Somewhat similar conclusions were reached by Furneaux (1952), and given mathematical expression by him. Furneaux claims that a person's test performance depends on three independent components--his intellectual efficiency, speed, and persistence. According to his findings no comprehensive

statement can be made about a person's ability to solve a problem which does not involve at least three componenents--assessments of $P_c$, $P_e$, and $P_s$ (Furneaux, 1952, p. 37). By $P_c$ he means the probability that a particular subject will continue to work at a particular problem for some time "t" before giving it up. $P_e$ is the probability that if the solution is recorded within this time it will be the correct one. $P_s$ is the probability that a particular correct solution will be returned within a period of "t" seconds after the moment the problem is presented.

Thus, from these findings, there is every reason to expect that a person's performance on problems does not depend on his intellectual efficiency alone, but also on his speed, and on his willingness to continue to search for an answer, that is, on what Vernon (1958) and Furneaux (1952) call his persistence. On this basis even relatively dull people could succeed with relatively difficult problems, provided they were willing to persevere; while relatively bright people might fail with relatively easy problems, provided they were unwilling to spend much time on the problem (Eysenck, 1953).

The evidence for this proposition is quite strong,

and it certainly agrees with common sense to say that high intellectual achievement is the product of high speed of mental work, combined with persistent application. Nevertheless, the two factors of speed and persistence are relatively independent, and consequently "power" cannot be used as a final unidimensional explanatory concept in psychology. Power is usually identified as the highest level of difficulty reached in the correct solutions of problems by a subject. It is clearly a compound concept dependent on the more elementary ones of speed and persistence.

What is the relevance of all this for the present thesis? Clearly if there are non-cognitive components in intelligence, and if, as Anderson (1958) has found these components are capable of showing very marked evidence of function fluctuation when measured in isolation, then it is a fair guess that they, while interacting with cognitive total-test performance, are responsible for the fluctuation observed in that performance. Further, if more speeded cognitive tests call for greater activity of these fluctuating non-cognitive components, then it might be expected that the extent of function fluctuation in cognitive tests which are

relatively speeded, is greater than the extent of function fluctuation in cognitive tests which are relatively power tests. In fact on the basis of indirect evidence Anderson (1960) has already made this suggestion, which is the first hypothesis to be tested in this study.

# CHAPTER III

## THE EFFECT OF BENZEDRINE* (AMPHETAMINE SULFATE) ON THE COGNITIVE AND NON-COGNITIVE PROCESSES

In the past few decades an extensive body of literature has been developed about amphetamine sulfate because of its therapeutic (clinical) applications and because of its value in psychopharmacological research. Bett (1950) points out that pharmacologists and psychologists are today studying its properties in order to understand better the "mechanism of thought-process" (1950, p. 43). Bradley and Green (1940) state that although amphetamine sulfate is, in many respects, a sympathomimetic drug, it has been considered by many a "stimulant of higher intellectual functions" (1940, p. 388) also. However, investigations of its effects on the higher intellectual functions have been reported in only a few publications.

The initial investigations on amphetamine sulfate were reported by Piness, Miller, and Alles (1930).

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*Amphetamine sulfate is issued in Canada and the U.S.A. by Smith, Kline, and French Laboratories as "Benzedrine Sulfate Tablets" and in liquid dosage form as "Benzedrine Sulfate Elixir." The amphetamine sulfate (Benzedrine) used in this study was kindly supplied by Hugh A. Sheppard of the Smith, Kline, and French Laboratories, Montreal.

Since that time, with the possible exception of the sulphonamides, penicillin, and streptomycin, it is doubtful whether any therapeutic agent of modern scientific medicine has aroused such vivid interest in professional circles and in the lay press. A veritable deluge of literature (Bett, 1946) has been published concerning its uses and abuses, its virtues, vices, and potentialities. Some relevant topics will now be considered.

## I. AMPHETAMINE SULFATE

Amphetamine sulfate is a sympathetic nervous system stimulant which is non-toxic, non-habit forming and effective on oral administration. It is chemically related to, and pharmacologically comparable with adrenaline and ephedrine. Amphetamine sulfate is systematically known as B-aminopropylbenzene, dl-oe-methylphenethylamine or phenyl-1-amino-2-propane. Its formula is $C_6 H_5 . CH_2 . CH (NH_2) . CH_3$. The structure of amphetamine confers on it resistance to enzymatic destruction in the body, as a result of which it is effective after oral ingestion and has a prolonged duration of action. (Bett, 1946; Goodman and Gilman, 1958).

## II. EFFECT ON MOOD AND ATTITUDE

Influence on mood is the most frequently reported effect. Ivy and Krasno (1947) describe this effect as ". . . a subjective feeling of augmented energy, relief from fatigue, mental stimulation, increased confidence loquacity, general expansiveness, optimism, and euphoria" (1947, p. 20). The most direct, objective and most extensive approach to the study of the effect of amphetamine sulfate on mood or attitude has been made by Carl and Turner (1939). They used forty-one men and one hundred and two women, divided into four groups. They gave one group a placebo and the others ten, twenty, and thirty milligrams respectively of amphetamine sulfate and applied the Bernreuter Personality Inventory and an optimism-pessimism scale. In general the drug heightened the mood, the interest, and the optimism and increased the willingness to work for long periods.

Discussing the emotional effects of amphetamine sulfate, Bloomberg (1939) describes the most common effect on the mood as a state in which one has "a sense of well-being, or a mild state of elation" (1939, p. 174). He feels that almost as common, but less widely emphasized,

is a marked tendency to garrulousness, not quite in the ordinary manic form of rush of speech with flights of ideas but rather like the sprightly chatter of the good conversationalist who knows he is good.

Barmack (1939) did several researches in an attempt to find what use amphetamine sulfate was in combatting boredom. In one study on thirty-six subjects, he found that ten milligrams of amphetamine sulfate [Barmack calls it "antihypnotic benzedrine sulfate" (1939, p. 495)] retarded the development of an unfavorable attitude to the task of adding pairs of six-place numbers. In a second investigation Barmack was interested in determining whether the effects of amphetamine sulfate on the work attitude could be duplicated with another type of repetitive task, such as pursuit-meter operation. The data demonstrate clearly that fifteen milligrams of amphetamine sulfate prevented the development of that condition which would have resulted in a report of boredom. The mean differences in the ratings on a scale of irritated-pleased between the amphetamine sulfate and placebo conditions suggest that amphetamine sulfate prevents the development of a feeling

of irritation. Barmack's data also suggest that the subjects felt their attention to the task was better sustained under amphetamine sulfate than under the placebo condition.

Perhaps Myerson (1938) best summarizes the influence of amphetamine sulfate on mood when he states that ". . . anhedonia is combatted, and, in general, life seems worth living" (1938, p. 101).

## III. EFFECTS ON LEARNING AND PERFORMANCE AS DETERMINED BY ACHIEVEMENT TESTS

According to Bakwin (1948) amphetamine sulfate results in a greater show of energy in a certain number of children. The children become more alert, show more initiative, more aggression in competitive activities, and a greater interest in their environment. From this description of the effects amphetamine sulfate has on the behavior of children, one would expect that their performance as determined by achievement tests would improve. This is, in fact, borne out by most research that has been done on this topic.

Molitch and Sullivan (1937) studied ninety-six boys (ten to seventeen years of age), using the Stanford

test. A week later fifty boys were given ten milligrams of amphetamine sulfate and the remainder a placebo, and then all were retested. Twenty-six of the fifty who showed no improvement were given twenty milligrams and retested. Of the control group 8.6 per cent improved on the retest; the group average decreased twenty-nine points. Of the treated boys, thirty-two per cent given ten milligrams improved an average of sixty-three points, and of those on twenty milligrams, ninety-two per cent improved an average of 117 points. No test of the significance of the difference was made.

Bradley (1937) gave twenty milligrams of amphetamine sulfate each day for one week to thirty children (five to fourteen years of age) with behavior problems. It was reported that fifty per cent improved in school performance and that the effect appeared forty-five to fifty minutes after the drug was given and disappeared in six to twelve hours. The work was devoid of controls.

McNamara and Miller (1937), using ten students, made quantitative tests of mental efficiency with multiplication problems (two three digit numbers). Twenty milligrams of amphetamine sulfate did not significantly increase the problems solved or decrease the errors,

though subjects reported subjective stimulation. Adequate controls were used.

Barmack (1938) using thirty-six students, also made quantitative tests of mental efficiency with addition problems (six places). The students, after having taken ten milligrams of amphetamine sulfate, solved a larger number of problems, although they made the same number of errors. Barmack used fifteen minutes instead of twelve minute work periods as did McNamara and Miller. Barmack had his students work for only two hours, whereas the other authors had their students work five hours in some instances. Barmack attributed the difference in results to the longer fifteen minute period of actual work. The present writer feels, however, that the difference might have reached the commonly accepted level of significance if the sample had been larger.

In general, school accomplishment is more satisfactory when amphetamine sulfate is administered. There is increased attention to academic work. Distractibility, fluctuations in mood, and day-dreaming are lessened. According to Bradley and Bowen (1940) performance in arithmetic was improved most, in spelling least. This effect according to Bakwin (1948), is produced by altering the emotional attitude of the child toward his intel-

lectual tasks rather than by stimulating the higher nerve centres.

## IV. EFFECT ON INTELLIGENCE SCORES

A series of writers (Bradley, 1937; Gorrell, 1939; Bakwin, 1948) describe the effect of amphetamine sulfate as marked improvement in speed of comprehension, accuracy of performance, and a keen desire for accomplishment. Kleitman (1939) studied the effect of amphetamine sulfate on "blocking," or the temporary pauses (three per minute) which occur when one is doing mental tests continuously. The results were not clear cut but there was evidence of less fatiguability, that is, faster performance and fewer errors. The effect appeared forty-five to sixty minutes after the subjects took the amphetamine sulfate, presumably ten milligrams, though no data are provided.

Molitch and Eccles (1937) working with ninety-three boys between the ages of eleven and seventeen and of varying mental levels, tested the boys at intervals before and after a placebo or amphetamine sulfate was ingested. Both groups improved* their scores; the children tested

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*Molitch and Eccles do not pay sufficient attention to tests of significance.

after taking amphetamine sulfate exhibited a greater improvement than those taking a placebo.

Sargant and Blackburn (1939), in a well controlled experiment demonstrated that patients under amphetamine sulfate showed an average increase of eight per cent in their intelligence test scores when measured by Cattell's intelligence tests. Sargant and Blackburn follow up their findings with a comment which appears to the author to have a firm psychological basis: ". . . of course there is no increase in intelligence, but there is increase in alertness, ability to concentrate, ability to make decisions quickly and in self confidence" (1939, p.1385). This observation has been abundantly confirmed.

Bradley and Green (1940) studied the effect of amphetamine sulfate upon the intelligence scores of twenty-one children. Following therapeutic oral doses of ten milligrams and twenty milligrams of the drug, performances on the revised Stanford-Binet scale were not significantly affected.

However, Bradley and Green do not feel that the results are insignificant. Other workers have observed that amphetamine sulfate has been effective in improving performance on similar tests. Bradley and Green feel

that the main difference in their study is that the children were familiar with the testing situation and were entirely at ease during the entire procedure which was carried out in surroundings to which they were quite accustomed (although none of the specific tests employed had been administered to these children). So frequently had they been tested for previous routine and special studies that they were not aware they were under special scrutiny when they were being tested on the Stanford-Binet. Bradley and Green suggest that the subjects of the study may have already been at their "optimum emotional readiness for testing which a single dose of the drug could hardly improve" (1940, p. 393). Had they been ill-at-ease or alarmed at the testing situation it seems that a definite improvement with amphetamine sulfate might have been noted.

An inference which might be drawn from this and the previously cited studies dealing with the effects of amphetamine sulfate upon intellectual performance is that when such performance is improved following the administration of the drug the result is accomplished primarily by an improved emotional attitude of the subject toward his intellectual task.

## V. EFFECT ON FATIGUE

There is no doubt that in the vast majority of normal subjects, wakefulness is promoted when five to twenty milligrams of amphetamine are taken. Bloomberg (1939) feels that there is not only wakefulness but insomnia. Most studies (Myerson, 1938; Bloomberg, 1939; Ivy and Krasno, 1941), however, point out that this wakefulness, and indeed insomnia, occur without fatigue and without the feeling that the lack of sleep is disturbing or exhausting. The effect of amphetamine sulfate in diminishing the sense of fatigue, is generally agreed to be due to an effect on the central nervous system and to be entirely subjective.

## VI. EFFECT ON VARIABILITY

Razran has claimed that stimulants such as amphetamine sulfate decrease the extinction of a conditional response (Mackworth, 1950). This led Mackworth to undertake an investigation to discover whether variability in performance during a visual vigilance task was affected by the administration of amphetamine sulfate. He studied twenty-four healthy naval subjects in a well controlled experiment. Each man did three two-hour runs of the

"Clock Test" (1950, p. 12) on successive days, once without any tablets, once starting one hour after taking two placebos and, on another occasion, one hour after swallowing two amphetamine sulfate tablets (ten milligrams). Mackworth concluded that:

> Ten milligrams 'Benzedrine' (amphetamine sulfate) taken by mouth one hour before the start of the test successfully maintains the initial level of accuracy over the whole two hours of the test. This is a pharmacological effect and is not due to any possible suggestion effect of knowing that one has taken some tablets which might affect efficiency (,950, p. 97).

Levy (1959), worked with one hundred children, which he described as being "variable, unpredictable, impulsive, and distractable" (1959, p. 1062). He found that amphetamine sulfate had a very ameliorating effect upon this variability of behavior.

This is the background for the second hypothesis that the extent to which performance on a cognitive test shows evidence of fluctuation is correlated with and determined by the extent of fatigue.

# CHAPTER IV

## EXPERIMENTAL DESIGN

This research contains two separate but related studies. The first which shall be referred to as 'Study I' deals with the writer's first hypothesis, that the extent to which performance on a cognitive test shows evidence of fluctuation is correlated with and determined by the extent to which a test is speeded. The second which will be referred to as 'Study 2', deals with the second hypothesis, that the extent to which performance on a cognitive test shows evidence of fluctuation is correlated with and determined by the extent of fatigue.

### I. THE TESTS

Two forms, Advanced 7 and Advanced 8 of the Moray House Intelligence Test, published by the University of London Press were used in both studies. The Moray House test was used in a study of English children by Anderson (1959). One of the reasons for using the same test was that if the results about the extent of function fluctuation were found to be comparable for this sample then findings about function fluctuation would be separately

applicable, that is, findings would have trans-cultural validity.

Both forms of the Moray House Intelligence Test consist of problems of the types used since the beginning of this century in the verbal tests of intelligence; directions, analogies, classification, sentence completion , series completion, jumbled sentences, deciphering codes, and miscellaneous problems including some arithmetic. There are no sections; problems of all kinds are presented one after the other in their order of difficulty. Both forms are designed to discriminate amongst children aged between twelve and one half years and fourteen and one half years. As one might expect from a product of a department organized by Sir G. H. Thomson, the test norms are based on representative sampling procedures and the reliability coefficients are very high.

## II. THE SAMPLE

### STUDY 1

The group used to test the first hypothesis were the Grade IX students from Salisbury High School, in an area in which there are both rural and suburban students.

TABLE II

NUMBERS OF STUDENTS PARTICIPATING IN STUDY 1

| | Experimental Group (AFF) | | Control Group (BFF) | |
|---|---|---|---|---|
| | Original Number | Number Present at all four Testing Occasions | Original Number | Number Present at all four Testing Occasions |
| Boys | 39 | 32 | 39 | 31 |
| Girls | 25 | 21 | 24 | 22 |
| Total | 64 | 53 | 63 | 53 |

Note:

The names of the students were divided into two groups on a random basis; one group was considered the experimental group and the other the control group.

## STUDY 2

Participants in the second study were the Grade VIII students from Campbelltown Junior High School.

TABLE III

NUMBERS OF STUDENTS PARTICIPATING IN STUDY 2

| | Code | Number of Students | |
|---|---|---|---|
| | | Original Number | Number Present at all four testing Occasions |
| Experimental Group | AFF | 29 | 25 |
| Control Group Number 1 (Placebo) | BFF | 30 | 28 |
| Control Group Number 2 | CFF | 30 | 17 |
| Total | | 89 | 70 |

Letters* were sent to each of the parents requesting them to either 'consent' or'not consent' to their child's participation in this experiment. Fifty-nine of the eighty-nine parents responded with a formal approval. These fifty-nine students were divided randomly (by the use of random numbers) into two groups. One group was considered the experimental group (coded AFF); the second group (coded BFF) were given placebos and were labelled control group number one. The thirty students whose parents had not consented, constituted control group number two.

## III. THE PROCEDURE

The testing was scheduled so that on four consecutive Wednesday afternoons the two forms of the Moray House test were to be administered. The final testing occasion, however, because of changes in the routine of school was on Thursday. Accordingly, the interval between each set of parallel tests was seven days except between the third and fourth occasions where it was eight days. On the first and third testing occasions,

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*Copy of letter in Appendix

for the two groups, form 7 was administered in the first half period of testing, form 8 in the second, with an interval of five to eight minutes between each test administration. On the second and fourth testing occasions the forms were divided so that both groups took 8 first, then 7 with a similar interval of time between administrations.

In an attempt to motivate the students, in both the control and experimental groups, it was explained to them that the test was British and that their performance would be compared with that of British children. Also, it was explained to the experimental group that they were being given twenty-two and one-half minutes to complete the test, while the control group were being given the standard forty-five minutes. At no time were either of the groups told that there would be any retests. When the testers arrived for the second testing occasion they explained that some of the students had done poorly and that it was expected that they could do better and so were being given a second chance. Before beginning the testing on the third occasion it was explained that most of the students had improved their score but that a few students had actually decreased, so, they were being given one final opportunity. In an attempt to keep the motivation on the fourth testing occasion at an optimum level the students were told that since the scores from testing occasion to testing occasion were extremely varied they would be discarded

and that the score achieved on this final test would be the only one considered.

In another attempt to arouse good motivation, the experimenter told the children, in response to their queries during the first testing occasion, that there was a relationship between the results of the tests and passing Grade IX.

## STUDY 2

A letter, explaining that an investigation into the effect on a child's school work of amphetamine sulfate was being carried out, was sent to the parents of all the Grade VIII children in Campbelltown School. The letter stated that amphetamine sulfate was a substance that helped the child to concentrate more on his studies for a short period of time and that it was medically just as harmless* as coffee and would have no after effects.

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*The great preponderance of competent clinical opinion favours the view that the incidence of undesirable reactions complicating the use of amphetamine sulfate in normal dosage range is negligible and that the few cases reported in the literature are usually traceable to indiscriminate use (Bett, 1946; Bakwin,1953; Levy,1959). In a number of children there is insomnia, but this wears off quickly. Occasionally dizziness, nauseau, and vomiting occur within a few hours of administration (Bradley and Bowen, 1940). But it must be emphasized that such an effect of unpleasantness is very infrequent.

The parents were asked to return the letter indicating whether they wished their child to participate in the experiment. Dr. Siemens, the Medical Director of the area in which the school is located, signed the letters.

The testing was scheduled so that on four consecutive Thursday afternoons the two forms of the Moray House test were to be administered as in the first experiment. The final testing occasion, however, because of changes in the routine of school, was on Wednesday. Accordingly, the interval between each set of parallel tests was always seven days except between the third and fourth occasions where it was six days. On the first and third testing occasions, for the three groups, form 7 was administered in the first half period of testing, form 8 in the second, with an interval of five to eight minutes between each test administration. On the second and fourth testing occasions the forms were divided so that all three groups took 8 first, then 7, with a similar interval of time between administrations.

On each testing day, one hour prior to the beginning of the testing, one capsule of amphetamine

sulfate (five milligrams*) was swallowed by each of the students of the AFF (experimental) group. Each member of the BFF (control number one) group was given a placebo, which in taste, color, and shape was identical with the amphetamine sulfate capsules. The administration of the capsules (amphetamine sulfate and placebo) was very closely supervised**. The CFF (control number two) group received no capsules.

The procedure used to attempt to motivate the students in the experimental and the two control groups was the same as that used in Study 1.

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*J. K. Martin, Professor and Head of the Department of Paediatrics, of the University of Alberta suggested this amount.

**The author is indebted to Hugh A. Sheppard, Research Director of the Smith, Kline, and French Laboratories, Montreal, for his valuable advice on some of the practical aspects of administering capsules to the students.

# CHAPTER V

## STATISTICAL TREATMENTS

### I. CRITERION OF FUNCTION FLUCTUATION

The test for evidence (criterion) used in this study is that originally suggested by Thouless (1936) and recently used by Anderson (1958). It can be approached descriptively in two ways: Firstly, the rationale behind Thouless basis statistic (the criterion) is that evidence of the fluctuation appears when changes in scoring between any two administrations of one test are correlated both in amount and direction with changes in scoring between the two administrations of the alternative parallel form. The formula suitable to this line of reasoning is that originally used by Brown (1910), $r_{(A_1-A_2)(B_1-B_2)}$. Another line of approach uses a simple model of scoring. Let $A_1$ and $B_1$ be measurements obtained at the same time from two intercorrelated (parallel) tests and $A_2$ and $B_2$ be measurements obtained at some other time from the same two tests. Then each individual has four scores: $A_1$ and $B_1$ on the first testing occasion, and $A_2$ and $B_2$ on the next. Thus, six correlations may be calculated: the within-day $r_{A1\ B1}$ and $r_{A2\ B2}$, between day $r_{A1\ A2}$ and $r_{B1\ B2}$ and between day

alternate forms $r_{A1\ B2}$ and $r_{B1\ A2}$. Experience with parallel forms of tests shows that both $r_{A1\ A2}$ and $r_{B1\ B2}$ are always less than one. It is safe to say that part, at least, of this failure of the correlations to attain the value of unity is due to the unreliability of the tests. Thouless (1936) attempted to determine whether a part has also been contributed by fluctuation of the function measured by A and B. He reasoned that day-to-day variation in the functions measured would also reduce all of the correlations between results obtained on different days but not between those obtained in the same day. Thus if test unreliability were the only cause of variation in the test results, $r_{A1\ B1}$, $r_{A1\ B2}$, $r_{A2\ B1}$, and $r_{A2\ B2}$ would all tend to be equal; if, however, day-to-day variation of the function measured were also present, $r_{A1\ B2}$ and $r_{A2\ B1}$ would tend to be less than $r_{A1\ B1}$ and $r_{A2\ B2}$. Fluctuation in a measurable psychological function can therefore be shown if $r_{A1\ B2}$ and $r_{A2\ B1}$ are significantly less than $r_{A1\ B1}$ and $r_{A2\ B2}$. Evidence for function fluctuation can be assessed by using Brown's (1910) formula $\left(r_{(A1-A2)(B1-B2)}\right)$, which would be tedious, or Thouless's (1936) more economical expression of it:-

$$\frac{r_{A1\,B1} + r_{A2\,B2} - r_{A1\,B2} - r_{A2\,B1}}{2\sqrt{(1 - r_{A1\,A2})(1 - r_{B1\,B2})}}$$

This quantity will be zero if there is no function fluctuation. The evidence for function fluctuation is, therefore, that this quantity significantly differs from zero.

Because there are four testing occasions and therefore six possible pairs of testing occasions (1 - 2, 1 - 3, 1 - 4, 2 - 3, 2 - 4, and 3 - 4) six criteria are available.

## II. INDEX OF FUNCTION FLUCTUATION

The amount of the criterion is partly dependent on function fluctuation but also on the size of $r_{AB}$, and so can not be used as a measurement of the amount of function fluctuation. Thouless (1936) suggests a statistic, which he calls the group index, as a measure of the amount of fluctuation. He points out that if $r_{AB}$ is small (through unreliability of the tests used or through their low saturation with the factor common to them), the criterion will also be small. In order to obtain an index of function fluctuation, therefore, the criterion must be divided by the mean of the same-

time correlations between A and B. The index is therefore:

$$\frac{\text{criterion}}{1/2 \left( r_{A_1 B_1} + r_{A_2 B_2} \right)}$$

or

$$\frac{r_{A_1 B_1} + r_{A_2 B_2} - r_{A_1 B_2} - r_{A_2 B_1}}{\left( r_{A_1 B_1} + r_{A_2 B_2} \right) \sqrt{1 - r_{A_1 A_2}} \sqrt{1 - r_{B_1 B_2}}}$$

The value of the group index of fluctuation is zero if there is no day-to-day variation of the mental function measured. Because the standard error of this index is complex and yields results not entirely satisfactory (Anderson, 1955), the test of significance is more appropriately applied to the criterion.

Because there are four testing occasions and therefore six possible pairs of testing occasions (1 - 2, 1 - 3, 1- 4, 2 - 3, 2 - 4, and 3 - 4) six indices are available.

# CHAPTER VI

## FINDINGS

### STUDY 1

The mean I.Q. of the control group was 103.53 ($A_1$*) with a standard deviation of 12.04. Because the experimental group was given only twenty-two and one-half minutes to write the Moray House test which is standardized on the basis of forty-five minutes, intelligence quotients were not calculated. However, since the students were assigned to groups on a random basis, it might well be expected that the groups were similar. The mean age of the control group was 14:6 and that of the experimental group was 14:7.

Table IV shows the mean scores and the standard deviations of the raw scores of the experimental and control groups on all the tests written.* It is evident from even a cursory inspection of Table IV,

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*$A_1$ represents the Advanced 7 test on the first testing occasion; $A_2$ represents the advanced 7 test on the second testing occasion, etc. $B_1$ represents the Advanced 8 test on the first testing occasion; $B_2$ represents the Advanced 8 test on the second testing occasion, and so on.

TABLE IV

MEANS AND STANDARD DEVIATIONS OF TESTS ADMINISTERED TO BOTH THE EXPERIMENTAL AND CONTROL GROUPS

| | Experimental Group | | Control Group | |
|---|---|---|---|---|
| Tests | $\bar{x}$ | S.D. | $\bar{x}$ | S.D. |
| $A_1$ | 35.30 | 11.27 | 57.75 | 14.98 |
| $A_2$ | 44.02 | 12.82 | 66.42 | 15.94 |
| $A_3$ | 51.23 | 15.34 | 66.34 | 17.23 |
| $A_4$ | 56.62 | 15.77 | 67.81 | 19.61 |
| $B_1$ | 27.85 | 11.28 | 44.28 | 14.98 |
| $B_2$ | 35.72 | 14.89 | 55.60 | 17.45 |
| $B_3$ | 40.84 | 15.21 | 58.87 | 19.13 |
| $B_4$ | 46.00 | 17.21 | 60.32 | 20.27 |

that the control group achieved a larger number of correct responses. These results are to be expected since the experimental group was permitted only twenty-two and one-half minutes while the control group was given the standard forty-five minutes. The Moray House test when administered in twenty-two and one-half minutes is clearly what is commonly termed a speeded test.

Intercorrelations of tests which were administered to both experimental and control groups are shown in Table V, page 41.

Criteria and indices, derived from all possible combinations of double tests and retests on four testing occasions, for experimental and control groups, are presented in Table VI, page 42. The facts clearly shown in this table are that although, in the experimental group none of the criteria are significant, five out of six are significant in the control group. It is also obvious that when the criteria of the experimental group are compared with the criteria of the control group, five of the six criteria are significantly different. The mean of the control group indices is .482 while the mean of the experimental group indices is only .062.

TABLE V

INTERCORRELATIONS OF TESTS ON THE SAME AND DIFFERENT OCCASIONS--EXPERIMENTAL AND CONTROL GROUP

Experimental Group N = 53

| Tests | $A_2$ | $A_3$ | $A_4$ | $B_1$ | $B_2$ | $B_3$ | $B_4$ |
|---|---|---|---|---|---|---|---|
| $A_1$ | .871 | .893 | .848 | .839 | .861 | .894 | .848 |
| $A_2$ | - | .900 | .886 | .839 | .856 | .883 | .850 |
| $A_3$ | - | - | .942 | .868 | .879 | .925 | .886 |
| $A_4$ | - | - | - | .855 | .903 | .919 | .896 |
| $B_1$ | - | - | - | - | .913 | .924 | .902 |
| $B_2$ | - | - | - | - | - | .943 | .913 |
| $B_3$ | - | - | - | - | - | - | .936 |

Control Group N = 53

| Tests | $A_2$ | $A_3$ | $A_4$ | $B_1$ | $B_2$ | $B_3$ | $B_4$ |
|---|---|---|---|---|---|---|---|
| $A_1$ | .864 | .860 | .780 | .869 | .853 | .828 | .797 |
| $A_2$ | - | .918 | .869 | .823 | .908 | .878 | .874 |
| $A_3$ | - | - | .925 | .832 | .915 | .944 | .936 |
| $A_4$ | - | - | - | .725 | .849 | .895 | .912 |
| $B_1$ | - | - | - | - | .881 | .854 | .782 |
| $B_2$ | - | - | - | - | - | .951 | .910 |
| $B_3$ | - | - | - | - | - | - | .940 |

TABLE VI

CRITERIA AND INDICES DERIVED FROM ALL POSSIBLE COMBINATIONS OF DOUBLE TESTS AND RETESTS ON FOUR TESTING OCCASIONS--EXPERIMENTAL AND CONTROL GROUP

| Combinations of Testing Occasions | Experimental Group | | Control Group | | Significance of Difference Between Criteria |
|---|---|---|---|---|---|
| | Criteria | Indices | Criteria | Indices | |
| 1 - 2 | - .024 | -.028 | .398** | .448 | * |
| 1 - 3 | .011 | .012 | .535** | .590 | ** |
| 1 - 4 | .131 | .151 | .591** | .663 | ** |
| 2 - 3 | .007 | .008 | .465** | .502 | * |
| 2 - 4 | - .005 | - .006 | .445** | .489 | * |
| 3 - 4 | .213 | .234 | .187 | .202 | N.S. |
| $\bar{x}$ | | .062 | | .482 | |

*Significant at the 5 per cent level. This notation is also used later to indicate other correlations equally significant.

**Significant at the 1 per cent level. This notation is also used later to indicate other correlations equally significant.

The difference between these two indices is significant at the .01 level. The first hypothesis is clearly not validated. Indeed, it is the reverse of the truth.

An attempt was made to determine whether the same amount of fluctuation is observed in the two sexes. Table VII shows the means and standard deviations of the tests administered to the boys of both the experimental and control groups.

TABLE VII

MEANS AND STANDARD DEVIATIONS OF TESTS ADMINISTERED TO BOTH THE EXPERIMENTAL AND CONTROL GROUPS

(Boys Only)

| | Experimental Group | | Control Group | |
|---|---|---|---|---|
| Tests | $\bar{x}$ | S.D | $\bar{x}$ | S.D |
| $A_1$ | 31.77 | 9.05 | 57.22 | 15.35 |
| $A_2$ | 40.03 | 11.16 | 65.66 | 16.55 |
| $A_3$ | 45.94 | 13.38 | 65.06 | 18.29 |
| $A_4$ | 51.71 | 14.59 | 64.75 | 22.20 |
| $B_1$ | 24.06 | 9.93 | 43.56 | 14.80 |
| $B_2$ | 30.06 | 12.32 | 53.00 | 17.37 |
| $B_3$ | 35.65 | 12.44 | 56.06 | 19.86 |
| $B_4$ | 39.61 | 15.10 | 57.03 | 21.65 |

Just as in the total sample the experimental group (Table VII) scored consistently fewer correct responses than the control group.

Intercorrelations of the tests which were administered to the boys of both the experimental and control groups are shown in Table VIII, page 45.

Criteria and indices derived from all possible combinations of double tests and retests on four testing occasions, for the boys of both the experimental and control groups, are presented in Table IX, page 46. Fluctuation as depicted by Thouless's (1936) criteria is far more evident in the control group than in the experimental group, with five of the six criteria being significant, whereas, none of the experimental group criteria are significant. In the experimental group the mean index is .001, while that for the control group is .496. The difference between these two means is significant at the one per cent level. Thus the fact which has already been demonstrated by the criteria, is verified by an analysis of the indices.

The means and standard deviations of the tests administered to the girls of the experimental and control groups are presented in Table X, page 47.

TABLE VIII

INTERCORRELATIONS OF TESTS ON THE SAME AND DIFFERENT OCCASIONS--EXPERIMENTAL AND CONTROL GROUPS

(Boys Only)

Experimental Group N = 31

| Tests | $A_2$ | $A_3$ | $A_4$ | $B_1$ | $B_2$ | $B_3$ | $B_4$ |
|---|---|---|---|---|---|---|---|
| $A_1$ | .849 | .889 | .802 | .787 | .795 | .836 | .782 |
| $A_2$ | - | .870 | .861 | .789 | .823 | .870 | .850 |
| $A_3$ | - | - | .915 | .824 | .853 | .881 | .855 |
| $A_4$ | - | - | - | .811 | .911 | .897 | .864 |
| $B_1$ | - | - | - | - | .884 | .906 | .851 |
| $B_2$ | - | - | - | - | - | .920 | .853 |
| $B_3$ | - | - | - | - | - | - | .906 |

Control Group N = 32

| Tests | $A_2$ | $A_3$ | $A_4$ | $B_1$ | $B_2$ | $B_3$ | $B_4$ |
|---|---|---|---|---|---|---|---|
| $A_1$ | .859 | .843 | .777 | .884 | .850 | .820 | .779 |
| $A_2$ | - | .906 | .890 | .827 | .902 | .868 | .842 |
| $A_3$ | - | - | .936 | .825 | .919 | .945 | .933 |
| $A_4$ | - | - | - | .744 | .864 | .910 | .909 |
| $B_1$ | - | - | - | - | .893 | .853 | .774 |
| $B_2$ | - | - | - | - | - | .951 | .907 |
| $B_3$ | - | - | - | - | - | - | .940 |

TABLE IX

CRITERIA AND INDICES DERIVED FROM ALL POSSIBLE COMBINATIONS OF DOUBLE TESTS AND RETESTS ON FOUR TESTING OCCASIONS--EXPERIMENTAL AND CONTROL GROUPS

(Boys Only)

| Combinations of Testing Occasions | Experimental Group | | Control Group | | Significance of Difference Between Criteria |
|---|---|---|---|---|---|
| | Criteria | Indices | Criteria | Indices | |
| 1 - 2 | .098 | .122 | .443* | .496 | N.S. |
| 1 - 3 | .039 | .047 | .605** | .661 | * |
| 1 - 4 | .169 | .205 | .600** | .669 | N.S. |
| 2 - 3 | - .093 | - .109 | .442* | .478 | * |
| 2 - 4 | - .259 | - .307 | .520** | .574 | ** |
| 3 - 4 | .039 | .045 | .089 | .096 | N.S. |
| $\bar{x}$ | | .001 | | .496 | |

TABLE X

MEANS AND STANDARD DEVIATIONS OF TESTS ADMINISTERED TO BOTH THE EXPERIMENTAL AND CONTROL GROUPS

(Girls Only)

| | Experimental Group | | Control Group | |
|---|---|---|---|---|
| Tests | $\bar{x}$ | S.D | $\bar{x}$ | S.D |
| $A_1$ | 38.88 | 14.37 | 58.57 | 14.35 |
| $A_2$ | 49.64 | 12.91 | 67.57 | 14.89 |
| $A_3$ | 58.68 | 14.82 | 68.29 | 15.27 |
| $A_4$ | 63.55 | 14.74 | 72.48 | 13.56 |
| $B_1$ | 33.18 | 10.91 | 45.38 | 15.19 |
| $B_2$ | 43.68 | 14.55 | 59.57 | 16.82 |
| $B_3$ | 48.41 | 15.61 | 63.14 | 17.10 |
| $B_4$ | 55.00 | 15.92 | 65.33 | 16.75 |

The interesting fact shown in this table is that although, as would be expected, the experimental group achieved fewer correct responses, the standard deviations on most of the tests are nearly the same as the standard deviations of the control group.

Intercorrelations of the tests which were administered to the girls of both the experimental and the control groups are set out in Table XI.

TABLE XI

INTERCORRELATIONS OF TESTS ON THE SAME AND DIFFERENT OCCASIONS--EXPERIMENTAL AND CONTROL GROUPS

(Girls Only)

Experimental Group N = 22

| Tests | $A_2$ | $A_3$ | $A_4$ | $B_1$ | $B_2$ | $B_3$ | $B_4$ |
|---|---|---|---|---|---|---|---|
| $A_1$ | .866 | .852 | .854 | .814 | .821 | .849 | .799 |
| $A_2$ | - | .897 | .880 | .838 | .839 | .857 | .797 |
| $A_3$ | - | - | .957 | .863 | .900 | .943 | .871 |
| $A_4$ | - | - | - | .858 | .865 | .925 | .899 |
| $B_1$ | - | - | - | - | .909 | .918 | .920 |
| $B_2$ | - | - | - | - | - | .941 | .912 |
| $B_3$ | - | - | - | - | - | - | .946 |

Control Group N = 21

| Tests | $A_2$ | $A_3$ | $A_4$ | $B_1$ | $B_2$ | $B_3$ | $B_4$ |
|---|---|---|---|---|---|---|---|
| $A_1$ | .874 | .898 | .867 | .846 | .877 | .865 | .871 |
| $A_2$ | - | .943 | .886 | .819 | .936 | .916 | .887 |
| $A_3$ | - | - | .939 | .854 | .920 | .951 | .962 |
| $A_4$ | - | - | - | .761 | .856 | .876 | .924 |
| $B_1$ | - | - | - | - | .876 | .877 | .833 |
| $B_2$ | - | - | - | - | - | .951 | .922 |
| $B_3$ | - | - | - | - | - | - | .935 |

Although most of the criteria for the girls of the control group are noticeably large, only three of the six criteria are significant (Table XII). However, it should be noted that if the N had been slightly larger at least two more of the criteria would be significant. Only one criterion is significant for the experimental group. In the control group the mean index is .464 while in the experimental group it is .271. The difference between the two means is not significant.

TABLE XII

CRITERIA AND INDICES DERIVED FROM ALL POSSIBLE COMBINATIONS OF DOUBLE TESTS AND RETESTS ON FOUR TESTING OCCASIONS--EXPERIMENTAL AND CONTROL GROUPS

(Girls Only)

| | Experimental Group | | Control Group | | |
|---|---|---|---|---|---|
| Combinations of Testing Occasions | Criteria | Indices | Criteria | Indices | Significance of Difference Between Criteria |
| 1 - 2 | - .027 | - .033 | .344 | .386 | N.S. |
| 1 - 3 | .205 | .233 | .348 | .387 | N.S. |
| 1 - 4 | .259 | .302 | .463* | .523 | N.S. |
| 2 - 3 | .157 | .176 | .481* | .510 | N.S. |
| 2 - 4 | .369 | .425 | .619** | .666 | N.S. |
| 3 - 4 | .479* | .520 | .294 | .313 | N.S. |
| $\bar{x}$ | | .271 | | .464 | |

Indices derived from all possible combinations of double tests and retests on four testing occasions, for the boys and girls of both the experimental and control groups, are presented in Table XIII, page 51.

An analysis of variance was performed to determine whether the observed differences between the sexes were significant. The difference (.270) between the means of the boys and girls of the experimental group was found to be significant at the five per cent level. The difference (.032) between the means of the boys and girls of the control group was not significant.

## STUDY 2

Some of the salient facts about the experimental group and the two control groups participating in Study 2 regarding intelligence and age are presented in Table XIV, page 52.

TABLE XIII

INDICES DERIVED FOR BOYS AND GIRLS FROM ALL POSSIBLE COMBINATIONS OF DOUBLE TESTS AND RETESTS ON FOUR TESTING OCCASIONS--EXPERIMENTAL AND CONTROL GROUPS

| Combinations of Testing Occasions | Experimental Group | | Control Group | |
|---|---|---|---|---|
| | Boys | Girls | Boys | Girls |
| 1 - 2 | .122 | - .033 | .496 | .386 |
| 1 - 3 | .047 | .233 | .661 | .387 |
| 1 - 4 | .205 | .302 | .669 | .523 |
| 2 - 3 | - .109 | .176 | .478 | .510 |
| 2 - 4 | - .307 | .425 | .574 | .666 |
| 3 - 4 | .045 | .520 | .096 | .313 |
| $\bar{x}$ | .001 | .271 | .496 | .464 |

TABLE XIV

THE INTELLIGENCE AND AGE OF
THE EXPERIMENTAL AND THE
TWO CONTROL GROUPS

| Group | Intelligence ($A_1$) | | | Age |
|---|---|---|---|---|
| | $\bar{x}$ | S.D | Range | $\bar{x}$ |
| Experimental (AFF) | 110.92 | 11.53 | 84-125 | 13:11 |
| Control No. 1(BFF) | 112.07 | 16.04 | 85-138 | 13:11 |
| Control No.2 (CFF) | 103.71 | 13.72 | 79-144 | 14:3 |

The means and standard deviations of the tests administered to all three groups are set out in Table XV, page 53.

TABLE XV

MEANS AND STANDARD DEVIATIONS OF TESTS ADMINISTERED TO THE EXPERIMENTAL GROUP AND THE TWO CONTROL GROUPS

| Tests | AFF | N = 25 | BFF | N = 28 | CFF | N = 17 |
|---|---|---|---|---|---|---|
| | $\bar{x}$ | S.D | $\bar{x}$ | S.D | $\bar{x}$ | S.D |
| $A_1$ | 64.76 | 15.62 | 64.96 | 18.33 | 56.00 | 16.96 |
| $A_2$ | 73.32 | 16.48 | 71.50 | 18.05 | 66.35 | 15.78 |
| $A_3$ | 72.24 | 14.93 | 75.75 | 17.44 | 72.64 | 15.62 |
| $A_4$ | 80.56 | 15.21 | 77.64 | 16.43 | 74.94 | 15.92 |
| $B_1$ | 55.52 | 17.70 | 56.18 | 20.39 | 51.24 | 15.82 |
| $B_2$ | 64.24 | 19.97 | 63.39 | 21.35 | 58.65 | 18.28 |
| $B_3$ | 70.20 | 18.81 | 69.36 | 20.02 | 65.71 | 17.75 |
| $B_4$ | 72.96 | 17.20 | 74.07 | 16.53 | 67.47 | .7.42 |

Even though the CFF group tends to have scores slightly lower than the AFF and BFF groups, all three groups appear to be very similar.

The intercorrelations of the tests on the same and different occasions of the three groups are set out in Table XVI, page 54.

TABLE XVI

INTERCORRELATIONS OF THE TESTS ON THE SAME AND DIFFERENT OCCASIONS--THE EXPERIMENTAL AND THE TWO CONTROL GROUPS

Experimental Group (AFF)

| Tests | $A_2$ | $A_3$ | $A_4$ | $B_1$ | $B_2$ | $B_3$ | $B_4$ |
|---|---|---|---|---|---|---|---|
| $A_1$ | .929 | .889 | .849 | .823 | .906 | .931 | .901 |
| $A_2$ | - | .934 | .890 | .806 | .917 | .955 | .944 |
| $A_3$ | - | - | .930 | .825 | .851 | .916 | .903 |
| $A_4$ | - | - | - | .793 | .824 | .869 | .879 |
| $B_1$ | - | - | - | - | .924 | .891 | .913 |
| $B_2$ | - | - | - | - | - | .958 | .957 |
| $B_3$ | - | - | - | - | - | - | .966 |

Control Group Number One (BFF)

| Tests | $A_2$ | $A_3$ | $A_4$ | $B_1$ | $B_2$ | $B_3$ | $B_4$ |
|---|---|---|---|---|---|---|---|
| $A_1$ | .929 | .911 | .883 | .922 | .906 | .927 | .896 |
| $A_2$ | - | .939 | .924 | .906 | .951 | .926 | .892 |
| $A_3$ | - | - | .979 | .886 | .947 | .957 | .935 |
| $A_4$ | - | - | - | .848 | .920 | .920 | .901 |
| $B_1$ | - | - | - | - | .940 | .914 | .914 |
| $B_2$ | - | - | - | - | - | .960 | .958 |
| $B_3$ | - | - | - | - | - | - | .959 |

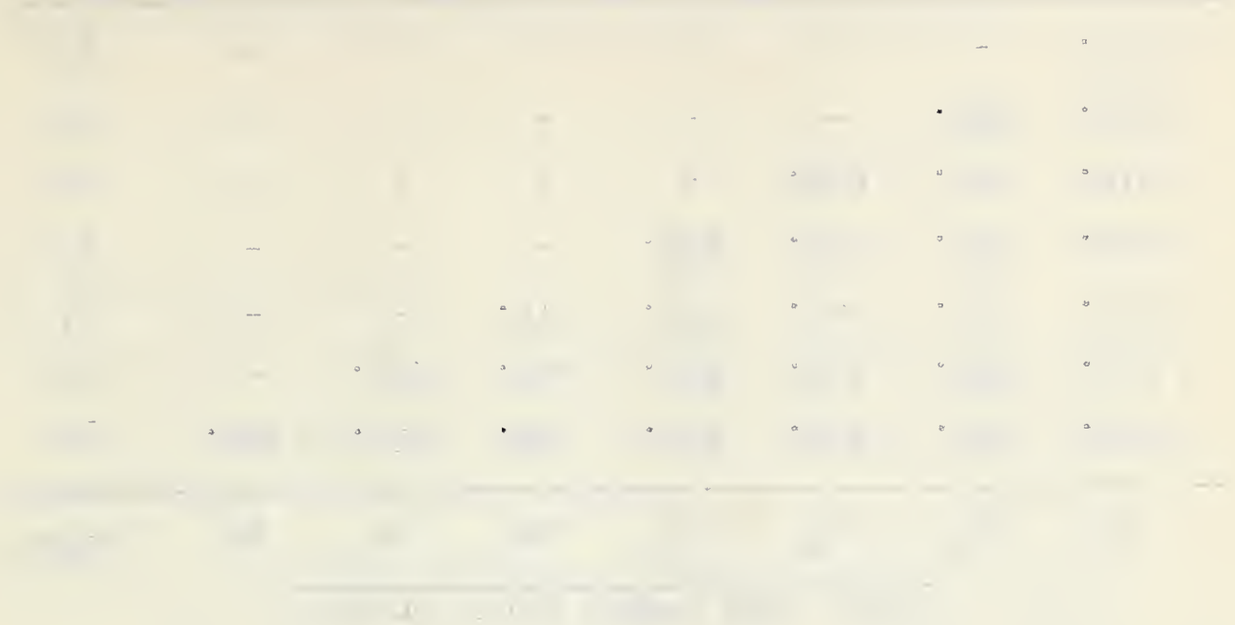

TABLE XVI (continued)

| | Control Group Number Two (CFF) | | | | | | |
|---|---|---|---|---|---|---|---|
| Test | $A_2$ | $A_3$ | $A_4$ | $B_1$ | $B_2$ | $B_3$ | $B_4$ |
| $A_1$ | .862 | .851 | .795 | .898 | .899 | .836 | .879 |
| $A_2$ | - | .925 | .901 | .824 | .944 | .860 | .892 |
| $A_3$ | - | - | .949 | .799 | .905 | .909 | .954 |
| $A_4$ | - | - | - | .762 | .909 | .881 | .945 |
| $B_1$ | - | - | - | - | .893 | .877 | .851 |
| $B_2$ | - | - | - | - | - | .942 | .932 |
| $B_3$ | - | - | - | - | - | - | .961 |

As indicated in Table XVII, page 56, both control groups have a number of significant criteria, whereas the experimental group has no significant criteria.

There is overwhelming evidence here (Table XVII) that the scores of the CFF group fluctuate more than those of the AFF or amphetamine sulfate group. The BFF group also showed more fluctuation than the AFF group.

TABLE XVII

CRITERIA AND INDICES DERIVED FROM ALL POSSIBLE COMBINATIONS OF DOUBLE TESTS AND RETESTS ON FOUR TESTING OCCASIONS--THE EXPERIMENTAL GROUP AND THE TWO CONTROL GROUPS

| | Experimental Group (AFF) | | Control Group No.1 (BFF) | | |
|---|---|---|---|---|---|
| Combinations of Testing Occasions | Criteria | Indices | Criteria | Indices | Significance of Difference Between Criteria AFF & BFF |
| 1 - 2 | .190 | .218 | .466* | .497 | N.S. |
| 1 - 3 | - .077 | - .089 | .377* | .401 | N.S. |
| 1 - 4 | .035 | .041 | .395* | .433 | N.S. |
| 2 - 3 | .257 | .280 | .354 | .371 | N.S. |
| 2 - 4 | .203 | .226 | .354 | .382 | N.S. |
| 3 - 4 | .236 | .263 | .051 | .055 | N.S. |

Control Group Number 1 (CFF)

| Combinations of Testing Occasions | Criteria | Indices | Significance of Difference Between Criteria AFF and CFF |
|---|---|---|---|
| 1 - 2 | .567** | .616 | N.S. |
| 1 - 3 | .637*** | .705 | *** |
| 1 - 4 | .577* | .626 | * |
| 2 - 3 | .677*** | .720 | N.S. |
| 2 - 4 | .537* | .568 | N.S. |
| 3 - 4 | .213 | .230 | N.S. |
| $\bar{x}$ | | .576 | |

The F-ratio was significant beyond the 1 per cent level of significance and so tests of the separate differences by the t-test were made. The results of these tests are shown in Table XIX.

TABLE XIX

RESULTS OF THE ANALYSIS OF VARIANCE OF THE INDICES DERIVED FOR THE EXPERIMENTAL AND THE TWO CONTROL GROUPS

| Groups | Difference Between Means | Significance |
|---|---|---|
| AFF - BFF | .199 | * |
| AFF - CFF | .421 | ** |
| BFF - CFF | .231 | * |

Thus not only was the difference between the control groups and the experimental group significant, but also the difference between the two control groups.

The F-ratio was significant at the 1 per cent level and so tests of the separate differences by the t-test were made. The results of these tests are shown in Table XIX.

TABLE XIX

RESULTS OF THE ANALYSIS OF VARIANCE OF THE INDICES DERIVED FOR THE EXPERIMENTAL AND THE TWO CONTROL GROUPS

| Groups | Difference Between Means | Significance |
|---|---|---|
| AFF - BFF | .199 | x |
| AFF - CFF | .421 | xx |
| BFF - CFF | .231 | x |

Thus not only was the difference between the control groups and the experimental group significant, but also the difference between the two control groups.

# CHAPTER VII

## CONCLUSIONS

1. Function fluctuation is active in cognitive functions to about the same extent in 'untreated' Canadians as in 'untreated' British children of comparable age studied by Anderson (1959, Table II, page 37).

2. A comparison of criteria derived from relatively speeded and relatively power tests of cognitive functions indicates that fluctuation is significantly more extensive in the latter. Thirteen out of eighteen criteria for the power tests are significant, while only one out of eighteen criteria for the speeded tests is significant.

3. A comparison of criteria derived from students having ingested amphetamine sulfate capsules and students having taken placebo capsules indicates that fluctuation is significantly more extensive in the latter. Fluctuation is even more significantly extensive in the group not taking any capsules. Clearly this finding could be stated in the words of the writer's second hypothesis that the extent to which performance on a cognitive test shows evidence of

fluctuation is correlated with and determined by the extent of fatigue. This is the only established correlate of fluctuation in cognitive functions.

4. The findings concerning sex differences in amount of fluctuation are rather inconclusive in that the difference between the boys and girls in the experimental group is significant, but that the difference between the boys and girls of the control group is not significant. An explanation of this phenomenon cannot be explained without further experimentation.

5. The extent of fluctuation in cognitive functions is unstable between different sets of testing occasions.

# CHAPTER VIII

## DISCUSSION AND IMPLICATIONS

There are two important conclusions to be drawn from the results: firstly, the first hypothesis that the extent to which performance on a cognitive test shows evidence of fluctuation is correlated with and determined by the extent to which a test is speeded, appears to be refuted and the second verified. A word is in order about each conclusion. The first conclusion does not necessarily negate the first hypothesis because the deduction which was proposed to test the hypothesis is not completely adequate for this purpose. The hypothesis stated that the greater the degree to which a test was speeded the greater the amount of fluctuation that would be observed. It was deduced from this that the amount of fluctuation observed in performance on a half test would be greater than that on a whole test. This omitted to take into account Zeigarnik's (Atkinson, 1953) phenomenon of closure*. Thus the pupils who

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*Good (1959, p. 102) defines closure as: a term in the gestalt description of behavior that signifies pattern completion, goal realization, the resolution of tension, or the process of effecting a balance.

took the half test were more strongly motivated to complete the test and thus, it may be hypothesized, would decrease fluctuation in performance by diminishing fatigue. Consequently as should be expected, and as later turned out to be the case, these pupils showed less fluctuation than the others who were allowed a longer time. The closure hypothesis, as an explanation of the observed results can be tested experimentally. If it is accurate, then the amount of fluctuation expected between later testing occasions, when the children were in sight of finishing the test, should be noticeably greater than the amount of fluctuation between the earlier testing occasions. An examination of Table XX supports this hypothesis.

TABLE XX

INDICES DERIVED FROM ALL POSSIBLE COMBINATIONS OF DOUBLE TESTS AND RETESTS ON FOUR TESTING OCCASIONS--EXPERIMENTAL GROUP

| Combinations of Testing Occasions | Indices | Mean | Difference Between Means |
|---|---|---|---|
| 1 - 2 | - .028 | | |
| 1 - 3 | .012 | .045 | |
| 1 - 4 | .151 | | |
| | | | .034 |
| 2 - 3 | .008 | | |
| 2 - 4 | - .006 | .079 | Not Significant |
| 3 - 4 | .234 | | |

The difference between the two means is not significant, but it is interesting to note that the indices between later occasions do seem to be larger, especially the index of .234 between the third and fourth testing occasions.

The second hypothesis is validated and this finding is congruent with the work of Mackworth (1950). Exactly why this relationship should occur would involve a discussion beyond the confines of this thesis. However, the present writer is inclined to speculate that this relationship lends plausibility to the work of Rapaport (1951). If hypercathexis (1951, p. 698) is a source of energy which allows greater intellectual performances, then fatigue could cause this amount of energy to fluctuate, attention to fluctuate, and performance to fluctuate. But, if amphetamine sulfate stimulates the person into a subjective sense of 'augmented energy and relief from fatigue' (Ivy and Krasno, 1947, p. 20) then the fluctuation is arrested; a finding with certain educational implications.

## I. IMPLICATIONS

1. More and more psychologists are going to have to concern themselves with the fact that functions

do fluctuate. When the tests of a fluctuating function are being used in a psychological experiment they should certainly be repeated several times and a mean arrived at before any statistical treatments are applied.

2. Alternatively, when an important educational decision is being made concerning any known fluctuation, particularly if the subject is at the borderline or threshold, it would seem advisable to test the subject after a medically acceptable dose of amphetamine sulfate has been administered.

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# A P P E N D I X

LETTER TO PARENTS

May 2, 1960.

Dear Parent:

Professor C. C. Anderson of the University of Alberta, in collaboration with Mr. Harvey Zingle of Colchester School in the Clover Bar School Division, hopes to carry out an investigation into the effect on a child's school work of amphetamine sulfate. This substance is similar in effect to the taking of a cup of coffee--it helps the child to concentrate more on his or her studies for a short period of time. It is medically just as harmless as coffee and will have no after effects.

Your son/daughter _____ has been selected to participate in this worthwhile experiment and I hope you will give your consent. Please return this letter with your signature in the box of your choice.

| I do not consent | I do consent |
| --- | --- |
| | |

Yours sincerely,

_____

MEDICAL DIRECTOR